TABLETS

OF

ANATOMY AND PHYSIOLOGY

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ANATOMY:

EAR, EYE.

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THESE UNPRETENDING LITTLE

TABLETS ON ANATOMY

ARE RESPECTFULLY DEDICATED BY THE AUTHOR TO THOSE FRIENDS WHO KINDLY TOOK HIM BY THE HAND, WHEN, QUITE A STRANGER, HE RETURNED TO HIS MOTHER COUNTRY, TWO YEARS AGO, AFTER AN ABSENCE OF TWENTY-THREE YEARS, AND ESPECIALLY TO

SIR W. FERGUSSON, BART.,
DR. FORBES WINSLOW, DR. RAMSAY,
DR. A. P. STEWART, DR. J. MURRAY,
DR. PLAYFAIR, DR. FINCHAM,
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MR. SAVORY, MR. J. COUPER, MR. HAYNES WALTON,
MR. FR. MASON, MR. HOLTHOUSE,
MR. G. E. LEGGE PEARSE,

AND TO ALL HIS COLLEAGUES AND FRIENDS AT THE WESTMINSTER HOSPITAL,

TO WHOM THE AUTHOR IS MORE PARTICULARLY INDEBTED.

OPINIONS OF THE PRESS ON THE LITHOGRAPHED EDITION.

"They present a mass of condensed information on Anatomy and Physiology, which will, we believe, be found very useful to students."—*British Medical Journal.*

"We can heartily recommend the Tablets to medical students for refreshing the memory on dry points of Anatomy and Physiology without the necessity of wading through descriptive text-books and wasting more than half the time expended on them in picking out the salient points."—*The London Student's Gazette.*

"The 'Tablets' place the essentials before the learner in the clearest and most concise manner, and we should advise all students who are preparing for the Primary at the College to obtain them."—*The Student's Journal and Hospital Gazette.*

"We do not hesitate for a moment to recommend the Tablets."—*Guy's Hospital Gazette.*

PREFACE.

THE demand which has been made for these Tablets, even in the rough lithographed form in which they were first scribbled out for Private Pupils, has induced the Author to print and publish without further delay, the Tablets on the Eye, the Ear, the Brain, the Cranial Nerves, the Perinæum, and the Surgical Anatomy of Inguinal and Crural Herniæ, which Tablets Students have more particularly asked for, and also those on Circulation, Respiration, and Animal Heat. The publication of the other Tablets in the printed form will have to be delayed for a while, as the Author cannot at present find time to revise them.

In a Learner's point of view Scientific facts may, the Author thinks, be divided into those which are daily met with by the Student, and which soon become familiar to him, and those which are learned with considerable pains, and afterwards easily forgotten.

The Author has endeavoured to deal with the latter class of facts only. *What every one knows, who has at all studied Medicine, he has purposely left out.* Greater condensation is thus obtained. To the non-medical reader these Tablets may appear disconnected, and the descriptions they contain (if descriptions they may be called) may seem dry and naked. The Author believes that the Student will easily supply the links, and give life and shape to the skeleton sketches.

Order and method have been carefully studied in the topographical arrangements of the headings, sub-heads, and main and minor facts. Words unnecessary to the sense have been suppressed.—The words printed in *italics* call attention to the salient points.

The Author is of opinion that Science can be studied to full advantage only in those larger and more comprehensive works, in which not only known facts are exposed, but also personal investigations and private

opinions are brought forward and discussed. He sincerely hopes that these Tablets will be found not only to assist Students in passing their Examinations, but also to encourage them to study substantial standard works.

GOWER STREET, *May*, 1872.

The teaching power of the Tablets has now been tested for more than a twelvemonth with the most favourable results by numerous Students preparing for the primary M. & F.R.C.S., and for the first M.B. examinations. The Author has therefore ventured to aim higher in his later tablets than he did in his former ones; the Tablets on Circulation and Digestion are in some respects still incomplete; those on Respiration, Animal Heat, the Secretions, the Nervous System and Development are more exhaustive, and the Author believes that they fully reflect the actual state of Science.

The Author begs to thank Mr. T. Cattell Jones, who was instrumental in making the lithographed Tablets known at Guy's Hospital, and who has kindly assisted him in correcting the proofs of the printed edition.

WOBURN PLACE, *April*, 1873.

ADVICE TO LEARNERS.

There is an art of learning as well as an art of teaching.

The grand secrets of this art are to classify and to condense the facts that are to be retained, and to proportion, according to their relative importance, the attention to be given to them.

Classify.—"Similia similibus" is a favourite tutorial motto with the author.—Group things that are alike: by learning one you will then learn a dozen. Mix not up those that are not alike, if you do not want to labour in vain.

Condense.—The more concise your wording is, the more facts you can learn in a given time, and the better you can learn them. Large books are not necessarily good books for study; they are intended principally for reference. A firm grasp of the facts of your science is what you want first; court erudition afterwards.

Proportion according to their relative importance the attention to be given to the facts that are to be retained. Master the headings & sub-heads first; then, in succession, the divisions, the sub-divisions, the principal points, the minor points, the noteworthy details, ... the minutiæ. Begin, not at the periphery, but in the centre; then radiate as far as your strength will allow you.

This method is pre-eminently suited to the preparation for examinations:

Examiners are men of high scientific standing; men whose time is valuable, and who make the best use of it. Their questions, especially in the viva voce examinations, are short & to the point; answers they want also short & to the point.—Ex.:

Q.—What bone is this? *A.*—The right cuneiform.

Four words to the question, three to the answer. The test is, however, a searching one; it shows whether the candidate recognises the cuneiform bone, and whether he is sufficiently acquainted with its surfaces, angles, borders, etc., to bo able to discriminate between a right bone & a left one.

What are the branches of the femoral artery? Of the internal maxillary?
What are the ligaments of the knee-joint?
What is the composition of bile, blood, urine?
What are the ordinary inspiratory muscles? What the extraordinary?

Now, if the studies have been conducted according to the rules above laid down, it is precisely such questions that the candidate is best prepared to answer.

These "Tablets" are destined to assist students in carrying out these rules.

The grouping of things that are alike, and the condensing, are done by the Author.

For the Student, there only remains to proportion according to their relative importance, the attention to be given to the facts that are to be retained. This, it is hoped, he will naturally be induced to do by the very topography of the Tablets; the Tablets, especially those on anatomy, show at a glance the general outline of the subject they treat of.* Let the Student look first at all the headings & subheads of the Tablet he is studying, and learn them well before going further. It is highly important, in the Author's opinion, to consider a subject as a whole, and to pass in review all its parts at one and the same time. It is, in fact, to inculcate this principle on the mind of the learner that the Tablets are built up, so to speak, each one on *one* page.

Woburn Place, *April*, 1873.

* The lithographed Tablets strike the eye more forcibly than the printed ones; they are, therefore, in that respect preferable.

EAR.

The External Ear

Consists of the pinna or auricle, & the external auditory canal.

Pinna or Auricle

Presents for examination the:—

Concha,—Central deep cavity, broad above, narrow below, leading into the auditory canal. It has in front of it the

Tragus,—A conical eminence frequently covered with hairs on its under surface; and behind it the

Antitragus,—A smaller eminence separated from the former by a deep notch, the incisura intertragica.—The

Helix,—The prominent curved margin of the pinna, internal to which is the

Fossa of the Helix,—A long narrow groove which follows the inner margin of the helix, and is bounded internally by the

Antihelix,—Another curved ridge broader than the helix, and which forms the posterior boundary of the concha. It bifurcates above, so as to enclose the

Fossa of the Antihelix, — A triangular depression comprised between the front part of the helix and the two divisions of the antihelix.

Lobule,—The soft pendulous portion of the auricle.

Structure of the Pinna or Auricle—Presents for examination the:

Cartilage of the Pinna.—Represents the greater part of the pinna, minus the lobule. The portions which form the concha and the tragus are also prolonged inwards to form the outer or cartilaginous portion of the external auditory canal. It is attached by dense fibrous tissue to the rough margin of the external auditory meatus of the temporal bone.

It is wanting between the tragus & the front part of the helix. It presents several fissures or slits: a vertical fissure on the lower & front part of the helix; a vertical fissure on the front part of the tragus; the helix and part of the antihelix are separated below from the antitragus by a deep vertical slit which cuts off a pendulous tail-like process, the processus caudatus; two or three irregular fissures, the fissure of Santorini, divide transversely the portion of the cartilage which enters into the structure of the external auditory canal.

Fibrous Tissue—Fills up the deficiencies of the cartilage, and bridges over the slits, forming the intrinsic ligaments.

Ligaments—The extrinsic ligaments are two in number, and connect the helix & the tragus to the root of the zygoma, and the concha to the mastoid process.

Muscles—Are:—

EXTRINSIC:—Attollens, Attrahens & Retrahens Aurem (v. Ms. of the Face).

INTRINSIC—Are six small bands of pale muscular fibres termed:

Helicis Major—Lies vertically upon the anterior border of the helix.

Helicis Minor—Lies obliquely upon the portion of the helix, which springs from the bottom of the concha.

Tragicus—Lies vertically on the outer surface of the tragus.

Antitragicus—Extends obliquely from the outer surface of the antitragus to the processus caudatus of the helix.

Transversus Auriculæ—Radiates on the cranial surface of the pinna, from the convexity of the concha to the prominence corresponding to the fossa of the helix.

Obliquus Auriculæ—Extends on the cranial surface of the pinna, from the convexity of the concha to prominence corresponding to the fossa of the antihelix.

Integument—Is closely adherent to the cartilage, and presents numerous sebaceous glands, especially in the concha & in the fossa of the helix.—With the subjacent areolar tissue it forms entirely the lobule.

Vessels & Nerves.—The vessels are derived from, or open into, the occipital, posterior auricular & temporal; the nerves are derived from the great auricular & auriculo-temporal, and from the auricular branches of the pneumogastric & facial.

External Auditory Canal

Is an irregular narrowing canal $1\frac{1}{4}$ inches long, and directed:—forwards & inwards,—inwards, backwards & upwards,—inwards, forwards & downwards in the first & second quarters, and in the second half of its course respectively (Sappey, Sœmmering). If, however, the pinna, and with it the outer or cartilaginous portion of the canal, be drawn upwards & backwards, the canal will be straightened to a great extent, and will then be seen to pass nearly directly forwards, inwards & slightly downwards. It is flattened from before backwards externally & from above downwards internally, and is narrowest towards its middle. Its floor is longer than its roof, owing to the obliquity of the membrana tympani.

Structure of the External Auditory Canal—The external auditory canal is formed of cartilage, fibrous tissue & bone lined by integument, and is divided into a cartilaginous & an osseous portion.

Its integument is thin and closely adherent, and presents hair follicles & sebaceous glands near the orifice, and also numerous ceruminous glands in the dense subdermic tissue of the cartilaginous portion. Its vessels are derived from, or open into, the posterior auricular, temporal & internal maxillary; its nerves are chiefly derived from the auriculo-temporal.

Cartilaginous Portion—Is about $\frac{1}{2}$ an inch long. It is formed by the prolongation inwards of the portions of the cartilage of the pinna, which form the concha & the tragus, and is firmly attached to the margin of the external auditory meatus of the temporal bone. The cartilage is deficient at the upper & back part of the canal, where it is replaced by strong fibrous tissue.

Osseous Portion—Is about $\frac{3}{4}$ of an inch long. It is formed below & in front by a curved plate of bone, which results from the extension outwards of the tympanic plate or ring of the fœtal bone. Its outer end is dilated, and presents a rough margin for the attachment of the cartilage of the pinna. The circumference of its inner end is marked, except at its upper part, by a narrow groove for the insertion of the membrana tympani.

The Middle Ear or Tympanum

Is an irregular cavity compressed from without inwards, situated between the external auditory meatus and the labyrinth, between the carotid canal and the mastoid cells, between the anterior surface of the petrous bone and the jugular fossa.

Outer Wall

Is formed by the membrana tympani, and by a small portion of bone surrounding it.

The membrana tympani is nearly circular, its vertical diameter being, however, rather the largest. It is obliquely directed downwards and inwards. Its circumference is contained in a groove which surrounds, except at its upper part, the circumference of the inner end of the meatus. It is formed of three layers, cuticular, fibrous, and mucous. The handle of the malleous descends between the inner and middle layers in their upper half, and draws the membrana tympani inwards.

Behind, and in front of, the upper part of the membrana tympani are the apertures of the iter chordæ posterius, and of the iter chordæ anterius, or canal of Hughier, by which the corda tympani enters and leaves the tympanum.

A little below the latter opening is that of the Glaserian fissure, which gives passage to the long process, or processus gracilis, of the malleus and to the laxator tympani muscle, the former being, in the adult attached by bone to the sides of the fissure.

Inner Wall presents:

A large rounded eminence, the promontory, formed by the projection inwards of the first turn of the cochlea; its surface is grooved for the passage of the branches of Jacobson's nerve.

Behind the promontory are seen, the fenestra ovalis above, and the fenestra rotunda below. The former leads into the vestibule, and is closed by the base of the stapes and its annular ligament. The latter leads into the scala tympani of the cochlea, and is closed by the membrana tympani secundaria.

Behind and between the two fenestræ is the pyramid, a small conical eminence, the apex of which presents an opening from which the tendon of the stapedius muscle, contained in the pyramid, is seen to proceed.

Above and behind the foregoing parts is a slight ridge which indicates the position of the aqueductus Fallopii as it passes backwards and then downwards in the 2nd and 3rd parts of its course.

Posterior Wall

Presents the openings of the mastoid cells.

Anterior Wall

Presents at its upper part the orifice of the canal for the Tensor tympani muscle and, below this, the opening of the osseous portion of the Eustachian tube. The two canals are separated by a thin plate of bone, the processus cochleariformis. The opening of the former is situated upon a small eminence, the anterior pyramid.

The Floor

Corresponds to the jugular fossa. It presents the small opening through which Jacobson's nerve penetrates into the tympanum.

The Roof

Is formed by a thin plate of bone, which corresponds to the anterior surface of the petrous bone.

The Ossicles of the Tympanum

Are three in number, the malleus, the incus, and the stapes.

The malleus and the incus, taking a general view of their arrangement, are elongated from above downwards, and from without inwards, and are parallel to each other and to the membrana tympani, to the upper part of which they correspond.

The malleus is situated in front of the incus, and adheres by its outer side to the membrana tympani, which it draws inwards.

The stapes is placed horizontally at the lower extremity of the incus, and is at right angles, or nearly so, with the incus and also with the malleus.

The three bones are joined by two delicate articulations; they are moved by four muscles (counting the laxator tympani minor as a muscle), and are held in position by four ligaments.

The Malleus presents a *head* which is attached to the roof of the tympanum by its suspensory ligament, and which articulates with the incus :—

A *Neck*, which gives attachment to the laxator tympani muscle (Gray, Quain).

The *manubrium* inserted between the mucous and fibrous layers of the membrana tympani ;—

The *processus gracilis*, which extends forwards and outwards into the Glaserian fissure and gives attachment to the laxator tympani muscle (Sappey, Gray). In the adult it is connected by bone to the sides of the fissure.

The *processus brevis* projects outwards towards the upper part of the membrana tympani, and gives attachment to the laxator tympani minor.

The Incus presents a *body*, which articulates with the head of the malleus, and is attached to the roof of the tympanum by the suspensory ligament of the incus ;—

The *long process*, which is nearly parallel to the handle of the malleus, and presents at its extremity a nodule of bone :—

The *Os orbiculare*, which is separate in the fœtus ;—

The *short process* attached by the posterior ligament of the incus to the posterior wall of the tympanum.

The Stapes presents a *head* articulated with the long process of the incus :—

A *neck*, into which the Stapedius muscle is inserted ;—

Two *Crurœ*, which connect the neck with the base ;—

The *Base*, connected by its annular ligament to the margin of the fenestra ovalis.

The Muscles of the Tympanum

Are four in number, counting the Laxator tympani minor :—

Tensor Tympani. Or.—From under surface of apex of petrous bone and from the cartilaginous portion of the Eustachian tube. Passes backwards and outwards in its canal, from whence it is reflected outwards over the processus cochleariformis.

Insert.—Into the inner part of the manubrium of the malleus near its root.—Suppld. by a br. from otic ganglion.

Laxator Tympani. Or.—From Spine of Sphenoid and from Eustachian tube ; passes backwards and outwards through Glaserian fissure.

Insert.—Into processus gracilis of malleus (Sappey), or into neck of malleus just above the processus (Gray, Quain).—Suppld. by tympanic br. of facial.

Laxator Tympani Minor. Or.—From upper and back part of meatus auditorius ext.

Insert.—Into the processus brevis and into the handle of the malleus.—Is generally considered to be only a ligament.

Stapedius. Or.—From the interior of the pyramid.—Emerges from apex of pyramid.

Insert.—Into back of neck of stapes.—Suppld. by tympanic br. of facial.

ACTIONS. The *Tensor tympani* draws inwards the manubrium of the malleus, and consequently the membrana tympani, and thus increases the tension of the latter. The *Laxators* produce the contrary effect. The *Stapedius* inclines the stapes backwards, and is believed to compress the fluid contents of the vestibule.

Vessels and Nerves of the Tympanum.

Arteries. The tympanic, from the internal maxillary, and the stylo-mastoid, from the posterior auricular, form a vascular circle round the membrana tympani.—The other arteries are small ; they are the potrosal branch of the middle meningeal entering through hiatus Falopii, twigs from internal carotid perforating posterior wall of carotid canal, twigs from ascending pharyngeal ascending along Eustachian tube.

Veins. Join middle meningeal and pharyngeal veins.

Nerves. Are :—a filament from otic ganglion to tensor tympani ;—tympanic branch of facial, to stapedius and laxator tympani ;—tympanic branch of glosso-pharyngeal or Jacobson's nerve ; supplies mucous membrane of tympanum, and gives off branches of communication to carotid plexus, great petrosal nerve and otic ganglion ;—chorda tympani.

The Internal Ear or Labyrinth

Consists of a series of cavities, the osseous labyrinth, channelled out of the substance of the petrous bone, and lined throughout by a thin fibro-serous membrane, the free surface of which secretes a lympid fluid, perilymph or liquor Cotunnii, in which fluid floats a closed membraneous sac, the membraneous labyrinth, which latter is very similar in shape to, but is smaller than, the osseous vestibule and semi-circular canals, and which is itself filled with a serous lympid fluid, endolymph. Some minute structures recently discovered in the cochlea also form part of the labyrinth.

Osseous Labyrinth

Consists of the vestibule, the semi-circular canals, and the cochlea.

Vestibule

Is the central cavity of the labyrinth. It is situated on the inner side of the tympanum. It communicates, in front, by a large opening, with the scala vestibuli of the cochlea, and behind, by five openings, with the semi-circular canals.

On its *outer, or tympanic wall,* is the fenestra ovalis, which is closed by the base of the stapes and its annular ligt., by which fenestra the cavity of the vestibule communicates with that of the tympanum.

Its *inner wall* presents in front a small circular depression, the fovea hemispherica, which corresponds to the saccule, and at the lower part of which several minute foramina, forming the macula cribrosa, are seen to give passage to the filaments of the saccular branch of the vestibular nerve; behind the fovea, and bounding it posteriorly, is a vertical ridge, the crysta or pyramidal eminence. Behind this is the opening of the aqueductus vestibuli.

On its *roof,* above and behind the fovea hemispherica, and separated from it by the pyramidal eminence, is the fovea semi-elliptica, a small transversely oval depression, which corresponds to the utricule, and presents another similar macula cribrosa for the passage of the utricular and ampullar branches of the vestibular nerve.

Semicircular Canals

Are situated behind and a little above the vestibule. They are three in number, and are termed respectively superior, posterior, external. Each one is at right angles with the two others.

outer, the latter at its inferior, extremity. They join at their opposite extremities, which open by a common orifice at the posterior and inner part of the vestibule.

The external semi-circular canal is horizontal, and directed outwards and backwards. It is ampullated at its outer extremity.

Cochlea

Is situated in front of the vestibule. In shape it resembles a snail shell.

Its base is directed inwards, and corresponds to the anterior of the two depressions at the bottom of the internal auditory meatus. It is perforated by numerous small openings for the passage of the filaments of the cochlear branch of the auditory nerve.

Its apex is directed forwards and outwards.

The cochlea presents for examination the modiolus or columella, the spiral canal, and the lamina spiralis.

THE MODIOLUS—is the central axis of the cochlea. It is conical in shape. Its base corresponds to the base of the cochlea, and presents the apertures above-mentioned. Its apex is situated within the last coil and at the apex of the cochlea, and it is expanded into a semi-funnel-shaped lamella, the infundibulum, which blends externally with the parietes of the cupola. Its outer surface forms the inner wall of the spiral canal. Its centre is channelled by the tubulous centralis modioli, and by numerous smaller canals for the passage of small arteries and of the filaments of the cochlear nerve.

THE SPIRAL CANAL—takes two turns and a half. It diminishes in size as it approaches the apex of the cochlea, and terminates in a closed extremity, the cupola. It has been described till lately as being divided by the lamina spiralis into two scalæ, the scala tympani and the scala vestibuli, the former of which is turned towards the base, and the latter towards the apex of the cochlea.

THE LAMINA SPIRALIS—Winds spirally round the modiolus. It presents an osseous part or osseous zone, broad at the base of the cochlea, much narrower at the apex, which zone extends from the modiolus about half way across the spiral canal, and is continued to the opposite wall by a membranous portion, or membranous zone. The osseous zone consists of two thin lamellæ of bone, between which are numerous minute canals for the passage of the filaments of the cochlear nerve. For the membranous zone see minute structures of cochlea.

The scala tympani is closed below by the membrane of the fenestra rotunda, and communicates with the aqueduct of the cochlea. The scala vestibuli communicates with the vestibule. The two scalæ communicate with each other at the apex of the cochlea by a common opening, the "helicotrema."

Membranous Labyrinth

Is a closed sac corresponding in shape to, but smaller than, the osseous vestibule and semicircular canals, in which it is contained. It floats in the perilymph, contains the endolymph, and supports the terminal ramifications of the vestibular branch of the auditory nerve, by which it is held in position. The canalis cochleæ of Reissner (see minute structures of the cochlea) communicates with the saccule, and is now described as a part of the membranous labyrinth.

Vestibular Portion

Consists of two sacs, the utricule and the saccule, which are generally believed to have no communication with each other.

The UTRICULE is the largest. It is transversely oval, and is situated behind the saccule, opposite the fovea semi-elliptica, at the upper and back part of the osseous vestibule. It communicates behind by five openings with the membranous semicircular canals.

The SACCULE is the smallest. It is globular, and is situated a little below, and in front of the utricule in the fovea hemispherica close to the opening of the scala vestibuli of the cochlea.

Membranous Semicircular Canals

Are similar to the osseous semicircular canals in number, form and situation, but are only about one-third their diameter. They open into the utricule to five orifices.

The membranous labyrinth is semi-transparent, and is usually described according to Kolliker as being formed of three layers; the outer layer containing the blood vessels, the terminal ramifications of the vestibular nerve and pigment cells, and being very similar to the outer layer or lamina fusca of the choroid; the middle layer being transparent and similar to the hyaloid membrane of the eye, but being slightly striated; the inner layer consisting of polygonal nucleated epithelial cells. Both Hirscheld and Sappey, however, recognise only an outer layer of connective tissue containing vessels and nerves and a few pigment cells, and an inner layer of pavement epithelium.—The walls of the utricule and saccule are thickest at the points where the filaments

of the vestibular nerve, are distributed to them, and they present at those points the [illegible]
a pulverulent calcareous material, the otoconia, formed of minute crystalline grains of carbonate of lime (Breschet). It is only in the lower vertebrata that the otoconia is collected into two hard masses or "otoliths" (Breschet, Sappey). A similar calcareous material exists in the cells lining the ampulæ of the semicircular canals. (Bowman).

The Auditory Nerve

Divides in the internal auditory meatus into two branches, the vestibular and the cochlear nerves.

Vestibular Nerve

Divides into three branches, the divisions of which branches pass through the small openings at the upper and back part of the cul-de-sac at the bottom of the internal auditory meatus, and are distributed to the utricule, the saccule, and the ampullæ opposite the masses of otoconia.

Cochlear Nerve

Divides into numerous filaments, which pass through the small openings at the base of the modiolus, and through the minute canals in its axis. These filaments bend outwards between the plates of the lamina spiralis, forming a plexus, in which ganglion-cells are found ; branches from this plexus perforate the lower edge of the osseous zone of the lamina spiralis, (habenula perforata) and form radiating bundles comprised partly within the osseous and partly within the membranous zone ; the terminal filaments of the cochlear nerve are believed to be connected with the spindle-shaped cells of the organ of Corti. (Kolliker).

The Arteries of the Labyrinth

Are first the internal auditory artery, a branch of the basilar artery or of the superior cerebellar, which artery presents a similar distribution to that of the auditory nerve, secondly branches from the stylo-mastoid artery. They form a minute capillary network on the walls of both the osseous and the membranous labyrinth.

The veins accompany the arteries.

The Minute Structures of the Cochlea

Were described by Reissner and by Corti in 1851, but they remained nearly unknown up to a comparatively recent date.

The membranous zone of the lamina spiralis is now known to be composed of two membranes, the membrana basilaris or basilar membrane, which bounds the scala tympani, and the membrane of Corti, which separates the scala media from the canalis cochleæ.

The membrane of Corti, membrana tectoria, arises from the inner part of the limbus laminæ spiralis or denticulate lamina of Todd and Bowman, which latter is a thick periosteal development, which covers the upper or vestibular surface of the osseous portion of the lamina spiralis in its outer fifth, and which presents numerous tooth-like processes. Between the denticulate lamina and the margin of the underlying bone is a groove, the sulcus spiralis, the lower edge of which it is that gives attachment to the basilar membrane. Both the Basilar membrane and the membrane of Corti are attached close together to the outer wall of the spiral canal, the ligamentum spirale (which is perhaps muscular in structure, Todd and Bowman) serving for the attachment of the former. Between the basilar membrane and the membrane of Corti is comprised a narrow canal, the scala media (Kolliker).

Another membranous partition, the membrane of Reissner, arising from the inner part of the limbus laminæ spiralis becomes also attached to the outer wall of the spiral canal, and cuts off from the scala vestibuli a three-sided prismatic canal, the canalis cochleæ.

The canalis cochleæ passes upwards into the cupola, where it ends in a blind pointed extremity, and downwards to near the vestibule, where it ends in the same manner; a small duct, the canalis reuniens (Hensen) joins its vestibular end to the saccule, and renders its cavity continuous with that of the latter.

The scala media contains the organ of Corti. This latter consists of rods and elongated cells which stand on the membrana basilaris on each side of an intervening space. The rods are arranged in two rows. They incline towards each other, and meet like the beams of a roof over the intervening space. Where they meet they are flattened, and form quadrilateral plates, which are directed outwards, those of the inner row overlying those of the outer, and both together presenting an appearance similar to that of the rows of keys of a piano.

The cells are arranged vertically, or in a slightly oblique direction, on each side of the rods, and have stiff cilia projecting from their upper extremity. The inner set of cells, cells of Claudius, form a single line. Those of the outer set, pedunculated cells of Corti, are three deep; a few spindle-shaped cells, cells of Deiters, are interposed between the latter.

A very delicate membrane, the membrana reticularis (Kolliker), mainly formed of squamous epithelial cells, extends from the line of contact of the rods to the outer wall of the cochlear tube. It is perforated by the cilia of the cells of Corti. Its use is supposed to be to keep the cells and rods in their places.

The remaining part of the basilar membrane is covered with hexagonal epithelial cells. Large epithelial cells also fill the sulcus spiralis.

The free edge of the osseous zone is perforated, just above the attachment of the basilar membrane, by numerous small apertures for the passage of the radiating branches of the cochlear nerve, and is termed the habenula perforata. The terminal filaments of the nerves are probably connected with the spindle-shaped cells of the organs of Corti.

EYE.

ppendages of the Eye and Lachrymal Apparatus.

he appendages of the eye are the eyebrows, eyelids & conjunctiva, and the lachrymal apparatus, which latter consists of the lachrymal gland, lachrymal canals, lachrymal sac & nasal duct.

Eyebrows.—Consist of thickened integument covered with oblique hairs.

Eyelids.—Two thin movable folds, separated by the *fissura palpebrarum*, the angles of which fissure form the *external & internal canthi.* The inner canthus is expanded into the *lacus lachrymalis,* in which are seen the *caruncula lachrymalis* & the *plica semilunaris.*—The edge of each eyelid is semilunar & thick (except opposite the lacus lachrymalis), and presents internally the *papilla lachrymalis* on the summit of which is the *punctum lachrymale.*

The upper eyelid is the largest of the two, and the most movable on account of its connection with the levator palpebræ superioris.

The eyelids consist of:—

1. Integument, subcutaneous areolar tissue, palpebral portion of the orbicularis;
2. Tarsal cartilages with the palpebral & tarsal ligaments, the tendo oculi & the tensor tarsi muscle;—and also, in the case of the upper eyelid the tendon of the levator palpebræ superioris.—The superior tarsal cartilage is the thickest, and is broadest in the middle; it gives attachment to the tendon of the levator palpebræ superioris. The inferior one is narrow, and nearly uniform in breadth.
3. Palpebral portion of the conjunctiva.
4. Meibomian glands and eyelashes.

Conjunctiva.—Presents an *ocular* & a *palpebral portion*, between which are comprised the *superior* & the *inferior palpebral folds*, of which folds the former is the deepest.

Ocular Portion—Is the thinnest and least vascular, and is subdivided into:

Corneal Portion—Consists almost entirely of an epithelial layer, the underlying membrane being extremely thin & transparent and intimately blended with the anterior elastic lamina of the cornea.—Its vessels form delicate capillary loops round the circumference of the cornea, over which, in the fœtus, they extend for some distance.

Sclerotic Portion—Is thicker and more vascular than the foregoing, but still transparent & nearly colourless, and is loosely connected to the globe.—At the inner canthus of the eye it covers the caruncula lachrymalis and forms the *plica semilunaris.*

Palpebral Portion—Is thick, opaque, & highly vascular, and presents numerous papillæ, which, when hypertrophied, constitute the disease called granular lids.

Lachrymal Gland — Is a conglomerate gland of the size & shape of an almond, and is situated in a depression of the outer & front part of the roof of the orbit.—It presents:—

Upper convex, & *under* concave surfaces.

Posterior border—Receives the vessels & nerves of the gland.

Anterior part, or Palpebral Portion—Is separated from the remainder of the gland by a slight depression, and is adherent to the upper eyelid & conjunctiva. It gives off from 6 to 8 excretory ducts which open into the upper fold of the conjunctiva.

Lachrymal Canals—Begin at the puncta lachrymalia on the summit of the papillæ lachrymales.—They pass respectively upwards & downwards for a short distance, and then bend inwards & open into the lachrymal sac.

Lachrymal Sac—Is the upper dilated part of the nasal duct. It lies in the lachrymal groove, and is crossed in front by the tendo oculi, and behind by the reflected aponeurosis of the same, & by the tensor tarsi muscle. It consists of a fibro-elastic coat lined internally by mucous membrane.

Nasal Duct—Is a membranous canal ¾ of an inch long, contained in an osseous canal formed by the superior maxillary, lachrymal & inferior turbinated bones. It is directed downwards, backwards & a little outwards, and opens into the inferior meatus. It is narrowest towards its middle. Its inferior orifice is partly closed by a fold of mucous membrane forming an imperfect valve.

THE EYE

Is formed of three coats or tunics and three refracting media or humours.

The outer coat is formed by the *sclerotic* and the *cornea*.

The middle coat is formed by the *choroid*, behind, and, in the anterior part of the eye, by the *ciliary processes* and the *iris*, on the outer side of which two latter are the *ligamentum pectinatum* and the *ciliary muscle*.

The inner coat forms the *retina*, which presents a prolongation non-nervous in structure, *the ciliary portion of the retina*, which latter extends as far forwards as the base of the iris.

The refracting media or humours are:—

The *aqueous humour ;*

The *lens* and its *capsule*, which are held in position by the suspensory ligament of the lens, or zonula of Zinn.

The *vitreous body* and its *hyaloid membrane*.

The External Tunic of the Eye.

The Sclerotic

Is a strong fibrous membrane thicker behind than in front, which covers the posterior $\frac{5}{6}$ of the eye.

Its *outer surface* is white and smooth. It gives attachment to the recti and obliqui muscles, and is covered in front by the conjunctiva.

Its *inner surface* is brownish. It is connected with the choroid by a very fine cellular membrane, the lamina fusca, and is marked by slight grooves for the passage of the ciliary vessels and nerves. In front, close to the cornea, it covers, and gives attachment to, the ciliary muscle, and presents a circular groove, which forms the outer wall of the sinus circularis iridis, or canal of Schlemm.

Behind, where the optic nerve penetrates into the eye, *i.e.* about $\frac{1}{10}$ of an inch to the inner side of the axis of the latter, it becomes continuous externally with the fibrous sheath of that nerve, and forms internally a thin cribriform lamella, the lamina cribrosa, which is perforated by small openings for the passage of the nervous filaments and of the arteria centralis retinæ.

In front it becomes continuous with the cornea by direct continuity of tissue, the latter membrane being slightly encroached upon by the sclerotic, especially above and below.

A few small blood-vessels permeate the fibrous structure of the sclerotic.

The Cornea

Constitutes the anterior sixth of the outer tunic of the eye, on the front of which it forms a slight hemispherical projection belonging to a smaller sphere.

It is nearly circular, being, however, anteriorly a little wider in its transverse than in its vertical diameter.

Its circumference joins the sclerotic by direct continuity of tissue, and is slightly overlapped by the opacity of the latter, especially above and below. Its posterior surface is, therefore, rather more extensive than the anterior, and is more exactly circular.

Its degree of curvature varies in different individuals, and is greatest in youth.

STRUCTURE OF THE CORNEA.—The cornea consists of a thick fibrous structure, the cornea proper, covered in front and behind by an elastic lamina and an epithelial coating.

The Cornea Proper—is formed of fibrous tissue continuous with that of the sclerotic, with which it is structurally homologous, its fibres being, however, softer and less distinct. It is divided into frequently communicating strata about sixty in number (Bowman), between which is found a homogeneous fluid material, which probably contributes to the transparency of the cornea. Pressure renders the cornea opaque by deranging the relative position of the strata, and modifying their relation to the fluid between them.

The Anterior and Posterior Elastic Laminæ (Bowman)—are perfectly transparent homogeneous membranes, very thin and brittle. When they are torn they curl up with their attached surface innermost.

The posterior elastic lamina gives attachment towards the periphery of the cornea to the fibres of white fibrous and elastic tissue (Bowman), which form the ligamentum pectinatum, give origin to the ciliary muscle, and constitute the inner wall of the sinus circularis iridis or canal of Schlemm.

The Anterior Epithelial Coating—is formed of two or three layers of transparent nucleated cells; the *posterior* of a single layer of cells only.

The blood-vessels of the cornea terminate in loops at its circumference. They are principally derived from the vessels of the conjunctiva; in man very few are derived from the ciliary vessels through the sclerotic (Kolliker).—The nerves, from 20 to 30 in number, are derived from the ciliary nerves, and pass into the cornea from the sclerotic; they at first retain their dark outline, but soon become transparent, ramify and form a net-work within the cornea proper.—Lymphatics are not known to exist in the cornea.

The Middle Tunic of the Eye

Is formed by the choroid, behind, and, in the anterior part of the eye, by the ciliary processes and the iris, on the outer side of which two latter are the ligamentum pectinatum and the ciliary muscle.

The Choroid

Is a vascular and pimentary membrane of a dark brown colour, thicker behind than in front, which lies between the sclerotic and the retina in the posterior five-sixths of the eye. It transmits the nerves and a part of the vessels, which supply the anterior parts of the eye.

Its *outer surface* is connected with the sclerotic by a fine cellular web, the lamina fusca.

Its *inner surface* is smooth and lies in contact with the retina.

Behind, it is pierced by the optic nerve.

It is continuous *in front*, opposite the fore-part of the sclerotic, with the ciliary processes, the iris, the ciliary muscle, and the ligamentum pectinatum.

STRUCTURE.—The stroma of the choroid is formed of a network of fusiform cells and of anastomosing star-shaped pigment cells (Kolliker), and may be divided into three layers as follows:—

External, or Venous Layer, contains a rich network of veins, the venæ vorticosæ, which form variously disposed curves, and converge towards four or five equidistant trunks, which latter issue from the eye-ball midway between the cornea and the entrance of the optic nerve. The larger branches of the short ciliary arteries pass forwards between the veins before they curve downwards to join the capillary layer.

Middle, or Capillary Layer, or tunica Ruyschiana, presents a very fine capillary plexus, the meshes of which are smaller and more delicate near the optic nerve than in any other structure, but become larger in front, in which situation they are continuous with those of the ciliary processes.

Internal, or Pigmentary Layer, consists of a single layer of remarkably regular hexagonal nucleated cells placed side by side, and so loaded with epithelimum that their nucleus can scarcely be perceived.

The lamina fusca contains a few star-shaped pigment cells, and is considered by Kolliker to form part of the choroid.

The Ciliary Processes

Form, with the ciliary muscle, which lies on their outer side, a thickened anterior annular portion of the second coat of the eye continuous in front with the ligamentum pectinatum and the iris, and marked on its inner or posterior surface by prominent converging plaits or folds, to which the above name is applied, which folds are intimately adherent both to the subjacent ciliary portion of the retina and suspensory ligament of the lens, the latter of which presents similar folds between which the ciliary processes of the choroid are received.

The ciliary processes consist of large and small irregularly alternating folds, numbering altogether between sixty and eighty, the number of the small folds being about one-third of that of the large ones.

Each fold or process presents a rounded inner extremity situated behind the peripheral portion of the iris, and an outer tapering prolongation which is lost on the inner surface of the choroid.

The ciliary processes are similar in structure to the choroid, but less vascular.

pectinatum and continuous with the ciliary processes, the ciliary muscle, and the choroid. This border is surrounded by a venous canal, the sinus circularis iridis, or canal of Schlemm ;

An inner edge, which forms the boundary of the pupil ;

An anterior surface variously coloured in different individuals, and marked by wavy converging lines ;

A posterior surface covered with a layer of dark pigment, the uvea.

STRUCTURE.—The iris consists of a stroma of circular and radiating unstriped muscular and connective tissue fibres, scattered through which are a few ramified pigment cells, and on the posterior surface of which is a thick layer of rounded pigment cells continuous with the pigmentary covering of the ciliary processes and choroid. It is still undecided whether in the adult the posterior epithelial layer of the cornea is prolonged over the anterior surface of the iris as it is in childhood. The radiating fibres of the iris are continued into the posterior elastic lamina of the cornea, forming festoon-like processes, which constitute the properly so called ligamentum pectinatum. The circular and radiating muscular fibres of the iris form what have been called respectively the sphincter and the dilator muscles. The arteries of the iris are derived from the long and anterior ciliary, and from the vessels of the ciliary processes. Its nerves are derived from the ciliary nerves, which break up in the ciliary muscle before entering the iris.

The Ligamentum Pectinatum

Is a structure first described by Hueck, which forms the principal connection between the middle and outer tunics of the eye.

It is formed of radiating fibres of elastic and connective tissue (Kolliker), which arise from the margin of the posterior elastic lamina of the cornea and from the point of junction of the sclerotic and cornea.

Some of these fibres pass into the iris, forming the festoon-like processes which constitute the properly so called ligamentum pectinatum, the others give origin to part of the fibres of the ciliary muscle, and form the inner boundary of the sinus circularis iridis, or canal of Schlemm.

The Ciliary Muscle

Is a yellowish-white ring of radiating unstriped muscular fibres, situated on the outer side of the ciliary processes and front part of the choroid.

Its fibres arise from the ligamentum pectinatum, and from the inner surface of the sclerotic close to the cornea.

They pass backwards and outwards, and join the choroid opposite and beyond the ciliary processes.

Beneath, and concealed by, the radiating fibres, is a ring of circular muscular fibres, which was long described as the ciliary ligament.

Ophthalmologists are far from being agreed as to the mode of action of the ciliary muscle. Some believe that it draws the lens and the whole ciliary apparatus forwards, and this is certainly the case in some birds (R. J. Lee) ; others believe that it relaxes the elastic suspensory ligament of the lens, and thus allows the latter to assume a more circular form (Helmholtz). The experiments of Helmholtz appear to prove that through the action of this muscle a change is produced in the shape of the lens, which change consists in an increased convexity and a projection forwards of the anterior surface of that body, and in the slightly increased convexity without or nearly without displacement, of its posterior surface.

The vascular and nerve-supply of the ligamentum pectinatum and ciliary muscle is the same as that of the iris.

The Retina

Is a delicate nervous membrane, thicker behind than in front, translucent and of a light pinkish colour when fresh, but becoming white and opaque very soon after death.

It lines in its posterior portion, or retina proper, the posterior $\frac{4}{5}$ of the eye, and is continued forwards as far as the base of the iris by its *ciliary portion*, a greyish membrane destitute of nervous elements, which is intimately blended with the ciliary processes, which lie in front of it, and with the peripheral portion of the suspensory ligament of the lens or zonula of Zinn, which lies behind.

Its *outer surface* is in contact with the pigmentary layer of the choroid.

Its *inner surface* rests upon the hyaloid membrane of the vitreous body.

In front the retina proper ends in a jagged margin, the ora serrata.

Behind, about $\frac{1}{10}$ of an inch to the inner side of the axis of the eye, the retina becomes continuous with the optic nerve, and presents a slight rounded eminence, the colliculus, which is formed by the expansion of the nerve fibres, and from the centre of which the arteria centralis retinæ is seen to emerge. Exactly in the centre of the posterior part of the eye, the retina presents an elliptical elevated yellowish spot, the yellow spot, macula lutea, limbus luteus of Sömmering, in the centre of which is a slight depression, the fovea centralis, formerly termed the foramen of Sömmering, on account of its presenting somewhat of the appearance of a hole.

STRUCTURE.—The retina presents for examination three layers, the membrana limitans and the fibres of Muller.

External or Columnar Layer, or Jacob's Membrane—is formed of rods perpendicularly disposed, intermixed between which are bulbous particles or cones, of which the broad ends rest upon the granular layer, while the pointed extremities are turned towards the choroid. Both rods and cones appear to be delicate cells with granular albuminous contents (Kolliker). To the base of each cone corresponds a pyriform cell, which forms the extremity of a fibre of Muller; whether the rods are similarly connected with Mullerian fibres is uncertain.

Middle, or Granular Layer—is formed of two strata of nuclear particles and cells containing a very large nucleus (Kolliker), which strata are separated from each other by an intermediate transparent layer slightly fibrillated in the vertical direction. The outermost stratum is the thickest. The

Internal, or Nervous Layer—consists of an outer stratum of nerve-cells, and of an inner stratum of nerve fibres, which latter stratum is formed by the expansion of the fibres of the optic nerve. The nerve-cells present from two to six ramified offsets, by which they are connected with each other, with the termination of the nerve-fibres, and with the corpuscles of the internal granular layer. The nerve-fibres are continuous with those of the optic-nerve; they are disposed in small radiating and inter-communicating bundles, which form a delicate web with narrow elongated meshes. They have lost their dark outline, and consist of an axis-cylinder only. They terminate by joining the offsets of the nerve cells.

Membrana Limitans—Is an extremely thin and delicate nucleated membrane, which separates the retina from the vitreous body. On its retinal surface it receives the insertions of the delicate fasciculi of connective tissue, of which it is now believed that the inner part of the Mullerian fibres consists.

Fibres of Muller.—Their history is still incomplete. Henle, indeed, believes that they are but artificial products, the result of coagulation by re-agents. They were first described as extending vertically from the ends of both the rods and the cones to the membrana limitans, becoming connected in their course with the nuclear particles of the granular layer; their connection with the rods is, however, uncertain. It would also appear that the vertical fibres described in the inner layers of the retina are only cellular in nature.

Over the Yellow spot the nerve-fibres are absent; Jacob's membrane is formed of cones only, and these are small, though closely aggregated.

Over the fovea centralis the granular layer is absent, as are also the fibres of Muller. The retina is, therefore, very thin, so much so that the dark pigment of the choroid is distinctly seen through it, so as to give rise to the appearance of a foramen.

The Ciliary Portion of the Retina is formed of elongated nucleated cells, with flat or forked bases resting upon the membrana limitans, which cells are believed by Kolliker to correspond to the above-mentioned pyriform cells of the Mullerian fibres.

The Arteries of the Retina are derived from a branch of the opthalmic, the arteria centralis retinæ, which pierces the optic nerve, passes forward among its fibres and through the porus opticus, and divides into four or five branches, which latter are at first situated between the retina and the membrana limitans, but soon pass between the bundles of nerve-fibres and form a delicate network in the stratum of the nerve cells. These branches extend as far forward as the ora serrata, where they form a circular capillary plexus (Kolliker), but not a distinct circular vessel, as is the case in some animals.

The veins follow the same course as the arteries.

The Humours or Refracting Media of the Eye

Are:
The *Aqueous Humour.*
The *Lens* and its *Capsule*, which are held in position by the suspensory ligament of the lens, or zonula of Zinn.
The *Vitreous Body* and its *Capsule or Hyaloid Membrane.*

Aqueous Humour

Differs little from water, for it contains but a very small amount of solid matter, chiefly chloride of sodium.
It fills the space between the cornea in front, and the lens with its suspensory ligament behind. This space forms in front of, and behind the iris, what used to be called respectively the anterior and posterior aqueous chambers of the eye. These terms were, however, based on an anatomical error, for the iris is now known to lie in the greatest part of its extent in immediate contact with the lens; the only space therefore which remains behind the iris to represent the posterior chamber is a narrow angular interval between the peripheral part of the iris, the suspensory ligament of the lens, and the ciliary processes.

The Lens

Is a double-convex transparent body, the convexity of which is greater on its posterior than on its anterior surface.
It is situated between the iris and the vitreous body, and is held in position by its suspensory ligament.
It is closely surrounded by its capsule.
Its *anterior surface* is in contact with the iris towards the pupil, but recedes slightly at the periphery.
Its *posterior surface* rests upon the vitreous body.
Its *circumference* is surrounded by the canal of Petit.

STRUCTURE.—The lens consists of superposed concentric layers, the density of which increases with their depth, the superficial layers being soft and almost pulpy, the central ones forming a hard nucleus.
These layers are formed of transparent flattened fibres, which adhere to each other by slightly serrated margins, and in some of which are found transparent nuclei.
They are divided in the fœtus and infant into three triangular segments, the planes of separation between which segments accurately correspond on each of the two surfaces of the lens, but do not correspond with the planes of separation of the segments on the opposite surface, being on the contrary so arranged that each plane on one surface corresponds to the interval between two of the planes on the

The fibres of each segment arise from the various points of the two planes bounding the segment, and pass to the periphery of the lens nearly parallel to each other. Having curved round the edge of the lens, they belong, on its opposite surface, to two different segments, and converge towards the boundary plane which corresponds to the bisecting line of the segment on the first surface. Thus the fibres do not pass from pole to pole, but from a plane on one side of the lens to a plane on the other. Those which arise near the pole on one side terminate near the peripheral extremity of a plane on the other, and vice versa.

In the adult the planes bifurcate and multiply, and the segments become more numerous. The arrangement of the fibres of each segment with respect to the planes remains, however, the same.

Capsule of the Lens

Is a transparent, structureless, elastic, brittle membrane, thicker in front than behind. When ruptured, it curls up with its outer surface innermost.

It closely surrounds the lens, from which it is, however, separated in front by a single layer of granular nucleated polygonal cells, which absorb moisture and break down soon after death, and thus give rise to the liquor Morgagni, wrongly described at one time as existing during life.

It gives attachment in front to the suspensory ligament of the lens, and is joined behind with the hyaloid membrane.

Suspensory Ligament of the Lens, or Zonula of Zinn

Is a firm, transparent, structureless membrane, which is attached in front to the fore part of the capsule of the lens close to its circumference, and which joins posteriorly the hyaloid membrane opposite the ora serrata.

Its anterior surface presents small radiating folds, the processus ciliaris zonulæ, which are received between the ciliary processes of the choroid.

Its posterior surface is separated from the hyaloid membrane by the canal of Petit.

The Vitreous Body and its Capsule, or Hyaloid Membrane.

The vitreous body fills the space between the retina and the lens, both of which it supports, and for the reception of which latter it is excavated in front.

It consists of a perfectly transparent albuminous fluid, enclosed in a delicate structureless membrane, the hyaloid, from the inner surface of which it has been said, but not proved—at least not in the adult—that delicate fibres are given off to form more or less perfect septa within the fluid part.

The hyaloid membrane is connected opposite the ciliary processes with the suspensory ligament of the lens; further inwards it forms the posterior boundary of the canal of Petit; behind the lens it is intimately united with the posterior lamella of the capsule of that body.